INSTALLATION & TEST OF A THREE-TON ICE MAKING PLANT

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INSTALLATION AND TEST OF A THREE-TON ICE MAKING PLANT

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PRESENTED BY

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I N D E X

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INTRODUCTORY

The modern engineer is rapidly beginning to recognize the superiority of refrigerating machines for producing the cooling effects for which natural ice is now employed. Such a machine can be used to make ice far more preferable both from the economic and hygienic standpoints, than the natural product. More often it is more convenient and economical to attain the cooling effect directly. By this means boxes and chill rooms are given a clean, dry coldness, which, when above the freezing point, preserves their perishable contents much longer than is possible with ice placed in an over-head bunker or in any other manner. Also if the allowable temperature range is small the refrigerating machine is the only practical medium.

In view of these numerous applications in commercial enterprises, it was thought advisable to introduce a study of these principles in a practical manner into the Laboratory Course of Experimental Engineering at the Armour Institute of Technology. To this end the equipment of an isolated, three ton ice-making plant was acquired. The installation of this plant was undertaken as the subject of this Thesis. Hereafter, it will become a part of the regular Mechanical Laboratory equipment.

Inasmuch as the available room and finances for

this purpose were small it was decided to install a machine involving the cycle of the compression system, rather than those of the vacuum or absorption cycles.

A principal of Physics that the vaporizing of a liquid will take up heat from surrounding objects is at the basis of all such machines. And all things considered, for practical purposes anhydrous ammonia is the best refrigerating agent. If one pound of anhydrous liquid ammonia is allowed to pass from a small orifice in the vessel containing it, into pipe lines where it expands to a gas, it will in vaporizing absorb over 500 British Thermal Units. But after havint done this work, the ammonia, now in a gaseous form, has exhausted its capacity of absorbing heat until it has been made very dense by compression and has been cooled by passing through pipes in contact with flowing water, so as to bring it back to liquid form.

BUILDING.

An adequate location, for this plant, was already provided for by the available space in the corrugated iron structure at 3323 Dearborn Street, which had been constructed for the M. C. B. draught gear testing machine. This location provided a floor space of 20' x 15' with head room to accomodate the indigenous piping. And with a small addition for the boiler, it would furnish sufficient room such that with careful designing the apparatus could be installed with but little congestion.

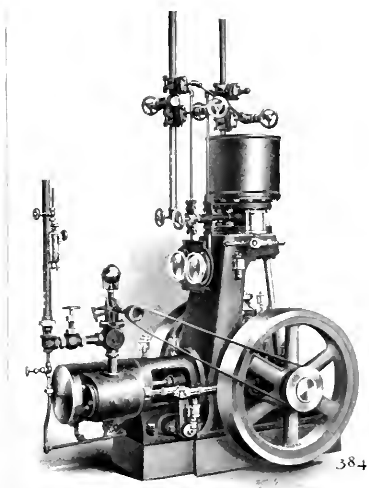
EQUIPMENT.

Boiler and Accessories:

The steam plant consists of a hand-fired, economic type boiler of 25 H.P. capacity, manufactured by the Eria Boiler Works, of Eria, Pa. The boiler has an available working pressure of 95 lbs. per square inch. The grate surface has an area of 10-1/2 sq. ft. A 40 ft. guyed, steel chimney of 12" internal diameter, provides for the smokeless combustion of anthracite coal only. Water is supplied to the boiler by a 3/4" Metropolitan injector from a water tank of 32 gallons capacity, which not only accomodates the water supply so that it may be used for other purposes, while water is being injected into the boiler, but also provides means for weighing the water.

Refrigerating Apparatus:

The refrigerating equipment for this plant was manufactured by the York Manufacturing Company of York, Pa. and consists maninly of a steam driven, single acting ammonia compressor, occupying a floor space of 5' - 3" x 2' - 9" and requiring head room of at least 7'. The compressor stands vertical and the steam cylinder horizontal, thus giving the whole unit the appearance of an angle compound steam engine as shown in Fig. 1. The machine has 6" steam and ammonia cylinders and a 6" stroke, the steam and ammonia cyclinders being double and single acting respectively. The steam cy-



Single Cylinder Machine
Steam-driven

Fig. I.

linder takes steam through an 1-1/4" pipe from the main header and exhausts through an 1-1/2" pipe to a 2" common header, that passes to the roof. An erie split ball throttling governor having a spring adjustment controls the speed of the engine which is rated at 130 r.p.m. Both steam and ammonia cylinders are provided with indicator connections.

The ammonia compressor is of the false or safety head type, quite similar to that shown in Fig. 2. An automatic suction valve is placed in the piston head and both it and the false head discharge valve are easily accessible by removal of the cylinder cover. A metal water jacket is the cooling medium for the compressor, water entering under pressure and discharging over the end of a 1/2" pipe where, by means of a by-pass it may be either weighed or discharged to waste.

All reciprocating parts are oiled by individual, gravity sight-feed oil wipers, while the main bearings, guides, etc., have individual sight feed adjustible oilers. The ammonia cylinder is lubricated by a hand-driven, force feed pump that delivers oil to the cylinder through a pipe leading into a cage at the top of the piston rod stuffing box. The oil forms a pool in the bottom head into which the piston dips and its reciprocating motion thoroughly oils the cylinder walls. Oil discharging into the discharge main is collected in an oil separator. The steam cylinder is provided with a sight feed, hydro static lubricator, connected to the steam pipe above the governor.

The ammonia condensor (Plate 7) is of the double

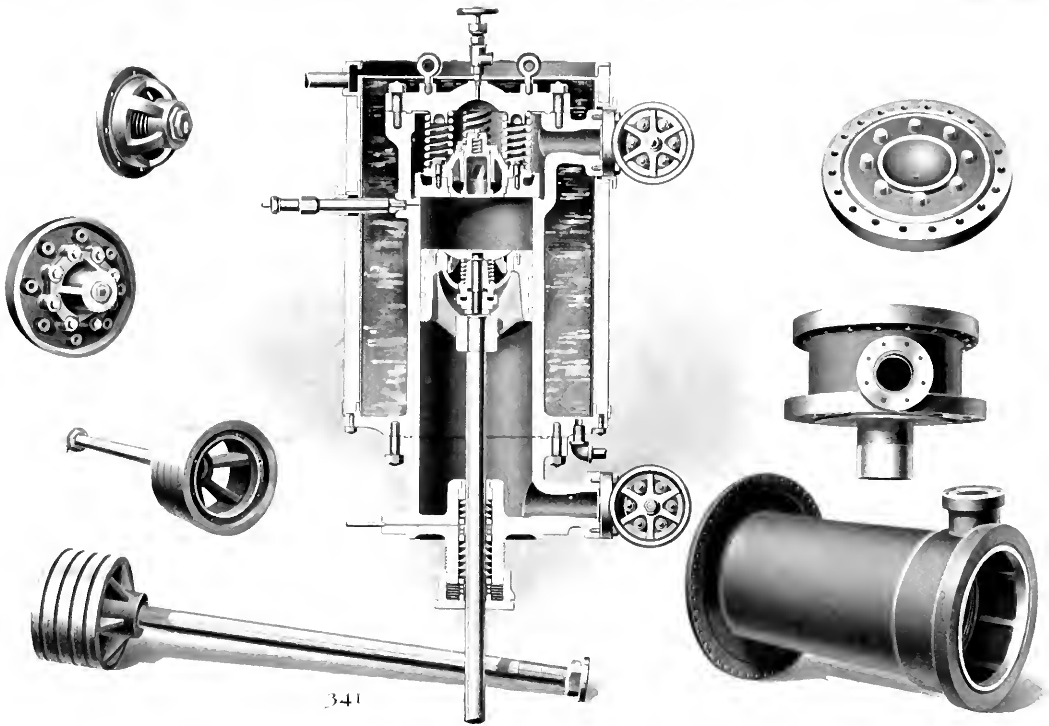


Fig. 2.

piped type, the ammonia being condensed in the annular chamber, between the inner and outer pipes. There are three pipes about 18' long and are connected at the ends by double return bends with removable water connections. The condensor is provided with floor stands to permit room for the receiver placed beneath it. The receiver (Plate 9) serves as a means for collecting the liquid ammonia as it flows by gravity from the condensor and also holds a reserve to compensate for unavoidable losses. It is 12" in dia. x 8' in length, is provided with floor stands, an automatic liquid ammonia guage, a drain and is made of extra heavy steel pipe, equipped with welded heads beaded in with solder at the joints.

A second receiver or accumulator (Plate 10) as it is termed, sets vertical upon a special floor stand and is made of 12" extra heavy pipe with a welded head at the bottom and an extra heavy tongue and grooved steel flanged head at the top. A coil of 3/4" extra heavy pipe is inserted in the accumulator, the inlet and outlet passing through stuffing boxes into top flange. It is also provided with an automatic liquid ammonia guage, a 3/4" drain and welded inlet and outlet ammonia gas connections.

The brine cooler (Plate 8), the last piece of apparatus in the system, consists of 6 double steel pipes having double return bends at the ends with removable brine bends. The cooler is held in shape by two bolted supports that are arranged to set on floor stands.

Water Circulating System:-

The complete equipment for the water circulating system includes the supply well or sump a Worthington Duplex Circulating Pump, a live steam closed water heater and essentially the condensor and cooler.

The sump is built of concrete 1:1-1/2:3 with a coat of neat cement on the inner surface. Its inside dimensions are 6' in length 4' in width and 4' in depth, giving it a capacity of about 720 gallons. The thickness of the walls and bottom is 8" except at one corner, where there is an enlargement, originally intended for a motor foundation. Over 3-1/2 cu. yds. of concrete were used in the construction of the sump. The floor boards rest on the top of the sump except at the motor foundation, which rises 3" above the floor.

The motor was not used and a Worthington Duplex Steam Pump No. 146,579 was installed in its place. The water end of the pump was placed on the motor foundation. The pump is of the low pressure type and is discharged by means of the throttle valve. Its size is 5-1/4 x 3-1/2 x 5". The steam lead is 3/4" and the exhaust pipe 1-1/4". It has a 2" water suction and a 1-1/4" discharge and the over-all length is 38" while its maximum height, above the floor is 20". Both ends of the steam cylinder are drained into the exhaust pipe and the inside ends of the water cylinder are also provided with drains. The water discharge valves are of the Poppet type with light springs. There are two valves for each end of each cylinder. The pump is supported on wooden foundations,

the blocks on the steam end resting on the floor. The steam cylinder is lubricated just below the throttle by means of a hydrostatic side feed lubricator. The ammonia condensor is of the double pipe style, consisting of a coil, three pipes high, and about 19' long. It is constructed of extra heavy ammonia pipe, 1-1/4" and 2" in diameter. The water flows into the smaller pipe and the ammonia is condensed around it. The inlet and outlet are on opposite ends and are provided with companion flanges.

The cooler or evaporator coil is of the same type, it being 6 pipes high and about 13' long. The same size pipes are used on it as on the condensor, the flanged connections for the inlet and outlet being onthe same end. The water flows in a small inner pipe, as in the condensor. Both condensor and cooler are about the same height above the floor to provide for proper draining symmetry and operating adaptability.

The heater is composed of a sheet steel cylindrical drum 5' in dia. and 10" in length with a straight, pipe steam coil throughout its length. The coil is composed of four 1" pipes about 4'-6" long, connected by three return bends and staggered in such a manner that a sheet iron diaphragm or baffle could be inserted between the second and third pipes and rivited to the sides of the drum. This baffle comes within about 6" of the end of the heater at the steam end and reaches to the end at the water outlet. The water enters the upper part of the end, flows through the baffle opening at the other end and then back to the end it started from through the

lower end. The steam connections are on the opposite end of the drum, the outlet leading through a 3/4" bucket high pressure steam trap No. 00 made by the Eureka Iron Company, Chicago. The connections of the pipes with the drum are made with lock-nuts and solder, the thread having been run on the pipe for several inches for the purpose. The amount of heat added to the water can be determined by the aid of thermometer cups place both in inlet and outlet water pipes. A cup is also placed in the steam outlet to obtain the temperature of the condensed steam. The amount of steam which is used is controlled by a throttle valve in the steam feeder and the trap discharge is piped so that the condensed steam can be weighed on small scales. The heater is placed, as shown in the drawing, at an elevation of 8'-5" above the floor.

Two steel weighing tanks, about 30" in dia. and 6' high, were added to the equipment to weigh the water circulated. They were placed on Fairbank's scales in the position shown in the drawing (Plate III). The capacity of both tanks together is about 425 gallons.

INSTALLATION.

Steam System:-

The design and installation of these systems involve the devotion of 750 hours in the aggregate, or an average of 250 hours per man. Care was taken in the design for convenience of operation and accessibility.

As steam is primarily the working medium, the installation of its system will be taken up herewith. The boiler setting consists of a concrete block, 8-1/2' long, 5' wide and 3' deep of a 1:3:6 concrete mixture. Water is supplied to the surge tank by a 1/2" pipe. A 1/2" pipe also is provided to feed the boiler while not in operation. The direct feed water pipe is of 3/4" diameter and is equipped with a check valve.

Steam is supplied to the plant through a 2-1/2" main header. A 1-1/2" pipe delivers steam to the compressor engine and pump, while a 1" pipe provides steam for the water heater and is by-passed to the atmosphere so that a boiler test may be conducted separately.

The 1-1/4" exhaust from the pump and the 1-1/2" pipe from the engine compressor are combined into a 2" exhaust main from which the steam is exhausted to the roof. Drains from the steam cylinder are piped into the exhaust mains and provision is made for draining the latter. The boiler blow-off is accomplished through a 1-1/2" pipe, provided with a blow-off cock and a blow-off valve.

This piping may be better understood by referring to Plate 1.

Ammonia Piping:-

The work requiring the most precaution on this plant was unquestionably the ammonia piping. The ammonia gas lines are all 1-1/4" extra heavy steel pipe and the liquid lines 1/2" extra heavy pipe. All flanged joints are of the tongue and grooved ammonia flanged type and in the make-up graphite covered rubber gaskets were used. The screwed joints on all ammonia connections were carefully examined and washed with gasoline before being made up with a mixture of litharge and anhydrous glycerine. By reference to Plate 2, the arrangement of the various parts may be seen and it will be observed that compactness was an essential requirement in view of the small space available.

The system was installed by a convenient arrangement of the large parts first and in such a way as to render all ammonia valves quickly accessible in case of emergency. The pipe lines were run after the setting of the large parts.

The erection of the compressor was first undertaken and for this it was necessary to construct wood forms for a concrete foundation, 5'-6" x 3' in plan and 3'-6" deep, as indicated on Plate 5. A wooden template, as shown on Plate 6 was hung on the concrete forms and this served to locate six 7/8" foundation bolts that were imbedded in the concrete. A 1:3:6 mixture of concrete was used for the foundation and after this was properly capped with neat cement and had hardened, the

engine was set in place, levelled up and a thin grouting run beneath the frame.

The brine cooler coming next in line to the engine was set on wooden floor stands, made of 2 x 4 lumber and rigidly supported. A few feet from this and parallel was located the condensor, for which floor pans were already provided. The receiver was sistuated beneath the condensor on two floor brackets and at its East end the most convenient position of the accumulator was selected. With the larger elements of the plant now arranged, the pipe lines could be set in. A set of first, class adjustable pipe dies were provided and extreme precaution was exercised in cutting each thread, particularly in the removal of oil and small steel shavings. Both the external and internal threads were quoted with litharge and glycerine and the joint was screwed up with a 4' wrench. The pump-out cross valve arrangement was set on top of the compressor and the discharge line was then run direct to the condensor; a thermometer tee being placed directly above the compressor and another at the condensor inlet. These thermometer receptacles are labelled T & T' on Plate 2. Two flanged ammonia valves (A) and (B) are also situated in this line with the oil separator placed between but near the condensor. The oil separator is provided with a 1" drain and 1/2" purge valve labelled (R) and (Q) respectively. The 1-1/4" ammonia liquid discharge line, from the condensor, contains thermometer receptacle T'' and after passing an 1-1/4" x 1/2 flanged reducer,

connects with the receiver through a 1/2" screwed angle valve (*C*). The receiver is provided with a 1/2" drain valve (*U*) made of screwed fittings and the liquid discharge is taken through a 1/2" pipe from a point 2" above the bottom of the receiver. A 1/2" screwed, cross valve (D) connects with this pipe and one branch passes to a 1/2" screwed charging valve (E). The other branch goes direct to the accumulator, passing through a 1/2" flanged valve (F) before entering the coil encased in the accumulator and consisting of 56' of 3/4" extra heavy steel pipe. The outlet reduces to 1/2" pipe above the accumulator after passing through a 1/2" flanged cut-out valve (*G*) the liquid is discharged through a 1/2" flanged expansion valve (H). A 1/2" x 1-1/4" reducer connects here and thermometer receptacle T''' gives the temperature of the ammonia gas as it enters the cooler. From cooler an 1-1/2" flanged ammonia valve (*I*) controlls the ammonia gas as it proceeds to the accumulator. Thermometer T'''' serves as a means for determining the temperature at this point. This gas, now being still cooler than the ammonia liquid in the accumulator coil, cools the liquid to a considerable extent and also precipitates any entrained liquid ammonia. The amount of liquid ammonia thus eliminated is indicated by the guage glass on the accumulator, and this can be withdrawn by a 3/4" drain valve. The ammonia gas leaving the accumulator, at the top, returns to the engine, its temperature being taken at thermometer cup T'''''. The valve (*J*) is an 1-1/4" cut-out on the suction over the engine. Valves (K) and (L) serve as a means for

cross connecting the suction and discharge for testing and for pumping out. Valves (M) and (N) are cutouts on the guage lines and their discharge pipes lead to a guage board on the South wall, where suction and discharge pressures are indicated. By reference to Plate 2 one may also trace out a complete cycle, by following the numbered arrows.

Installation of Water System:-

It being impossible, with the present equipment and lack of room, to have separate systems for the cooling water and brine, one complete system embracing both was employed. In the condensor the water is heated and in the evaporator it is cooled. Since the refrigerating effect is determined by the quantity of heat transferred in the cooler, the use of water is as satisfactory as that of brine, provided the temperature in the cooler is maintained above the freezing point of water. Moreover water in the cooler has the advantage in that its specific heat is more constant for the same variations in temperature than that of brine.

In order to keep the temperature, in the cooler, above 32 degrees and also to increase the flexibility of the plant for testing purposes, a live steam, closed water heater was installed in the system between the condensor and the cooler. For ordinary running, if the water is circulated fast enough, the heater need not be used. Again, if the circulation is slow and the amount of ammonia evaporated is small, the heater is unnecessary as the cooling in the expan-

sion coils will be less than the heating in the condensor. Under full load, however, with slow water circulation, the heater will have to be adhered to.

As the lead from the City water main is only a 1/2" pipe it was necessary, in order to obtain the required amount of circulation, to have a larger source of supply and a means of providung the necessary flow. To this end the concrete sump was constructed and the duplex pump installed. The sump is filled from the 1/2" connection to the city main, as shown. This same pipe also leads to the boiler room to supply the feed water and to the compressor cylinder water jacket. The latter connection is made at the bottom of the jacket just below the indicator valve, the water rising in the jecket to the cylinder head and then overflowing in a small pipe. This overflow is by-passed to the sump, but is arranged so that the water can be weighed. The temperature of the water is obtained at both inlet and outlet so that the amount of cylinder cooling can be determined. As the head of the water is only about a foot, the thermometer cups consist simply of rubber stoppers, forced into pipe tees, the stoppers having holes in them for the insertion of thermometers.

As previously stated, the sump was constructed of concrete with a 1:1-1/2:3 mixture. The mixing was done by hand on the platform and forms were made of 7/8" plain lumber, reinforced by 2 x 2 timbers. Although the mixture gave concrete of sufficient water proofed quality, an additional coat of

neat cement was applied to the outside surface. This not only made it water-tight but added to its appearance. It was at first intended to have an electric motor and a small rotary pump for the circulation, and the foundation with its anchor bolts was accordingly constructed. It was learned later, however, that current could only be obtained 18 hours out of each day and as the tests will have to be of longer duration than that, it was decided to make the plant complete independent. With this in view the steam pump was accordingly installed. The anchor bolts were broken off and wooden foundations made for the pump. The wooden foundation is sufficiently strong as at the low speed at which the pump is operated, the shaking forces are negligible.

The tanks and weighing scales were added to equipment for measuring the amount of water circulated. They were placed in the position shown, to give the desired passage room through the door way, and also so that they could be drained directly to the sump. The complete water circulation can now be traced.

The pump draws the water from the sump through a 2" suction pipe. This pipe reaches to within 1/2" of the bottom of the sump which is made low at this point. At the suction end of the pipe a strainer was placed to keep any large material from entering the system. This strainer consisted merely of a tin can with a great many small holes drilled in it. The pump then forces the water through a 1-1/4" pipe into the condensor, which it enters at the bottom and leaves at the top

on the other end. This makes the water flow counter-current to the ammonia flow, giving the best results. Thermometer cups and valves are placed in both inlet and outlet pipes of the condensor, the former being between the condensor and the valves. The water then enters the heater at the top and leaves at the bottom, as stated before, thermometer cup being placed in both intlet and outlet pipes. From the heater the water drops to the top of the cooler where there is another valve and thermometer cup. The water in counter-current with the ammonia, enters at the top and leaves at the bottom of the cooler, the flanged connections for both inlet and outlet being on the same end. A thermometer cup and valve are placed next in order and the pipe then drops to the floow extending to the opposite end of the cooler, where it rises to a height of 7' and then leads to the weighing tanks. A three-way valve is placed at the first tank so that the water can be discharged into either tank desired.

All water piping is arranged so that it can be drained into the sump and from there pumped out. Between the pump and condensor, as near the former as practicable, a tee and nipple were placed, which connect with a three-way valve. The outlet leading straight down serves as a drain for the piping from the pump through the condensor and to the heater. The other pipe is the pump out which discharges the water at the South end of the boiler house. By means of this line all of the water in the sump can be discharged out of doors except a small amount which would drain back from the suction pipe and

pump-out riser when the pump was stopped. At the bottom of the pipe, which rises to the heater, is placed a 3/4" pipe and valve leading out of doors. This serves as a drain for the upper part of the heater and also as an air vent to admit air to the system in draining. In the outlet pipe from the cooler and other drain, with 1" pipe and valve was placed. The drain, which leads to the sump drains the water from the lower part of the heater, cooler and discharge piping to the weighing tanks.

All water circulating piping, except the drains and suction pipe, are of 1-1/4" standard pipe with joints made up with plumbago and oil. There are 12 globe valves in the system and two 3 way cocks. These valves and cocks are of two makes, viz. Jenkins Brothers and Scott Valve Co. At present floor boards cover the sump but later this will be changed to lattice form so that the condition of the sump can be easily observed. The water system includes, when under test, nine temperature readings and the use of four scales for weights counting the feed water and jacket water scales.

Test of Installation:-

The installation being complete, the plant was put into operation, all lubricators and valves being properly adjusted. The entire ammonia system, up to the acculator, was tested out under 275# air pressure and no appreciable leakage could be detected by the soap-water test. This pressure was then relieved and 210# put on the pressure system and 20" of vacuum on the low pressure system. The plant was then shut down with the pressure and vacuum maintained by means of the valves. The pressure dropped about 1-1/2# per hour and the vacuum about 1" in six hours. These results indicated that the installation was quite satisfactory.

PROCEEDURE OF A TEST.

To conduct a test on this plant it is obvious that we should start with the coal pile where the coal must be weighed into the furnace and samples for analyses taken at convenient intervals. The ash must be weighed out and samples taken occasionally. Feed water made up in a barrel is weighed as used. A constant steam pressure of 95# is maintained on the boiler and by no means should the safety valve be allowed to pop nor should the blow off valve be opened. Assuming that the system has been pumped out, the engine really started and a good vacuum maintained. Liquid ammonia can then be admitted to the receiver and system and purge valves opened after vacuum is relieved. The ammonia discharges from the purges after all air is expelled and at this time they should be closed and the suction and discharge valves opened. The expansion valve is set so as to maintain about 20" of vacuum on the suction side and the discharge run up to 150# pressure. By starting the duplex pump water may be turned on the condensor and on the cooler, provided water is used. When the receiver becomes about one half full of liquid ammonia the charging valve may be cut off, and at this point it is estimated that it would require about 6 25# flaska of ammonia to charge the plant, making a net cost of $150.00. The water heated in the condensor may be further heated in the heater installed for the purpose in case the heater extracts more heat than is provided by the condensor. The condesate from

from the heater is discharged from a trap. The plant should be operated long enough for all conditions to become constant and then the following readings should be taken at intervals, depending upon the duration of the test:

Weight of Coal,
" " Feed Water,
" " Ash,
" " Heater Condensate,
" " Water Cooled in System,
Temperature Feed Water,
" Calorimeter at Boiler,
" " " Engine,
" Compressor Inlet Jacket Water,
" " Outlet " "
" Ammonia Gas at Compressor outlet,
" " " " Condensor Inlet,
" " Liquid at " Outlet,
" " Gas at Cooler Inlet,
" " " " " Outlet,
" " " " Compressor Inlet,
" Water Inlet to Condensor,
" " Outlet of "
" " Inlet to Heater,
" " Outlet of Heater,
" Heater Condensate,
" Water Inlet to Cooler,
" Water Outlet of Cooler,
" Engine Room,
" Outside Air,
Steam Pressure at Boiler,
" " " Throttle,
" " " Heater,
Barometric Pressure,
Pressure of Ammonia Discharge.
" " " Suction,
Revolution Counter,
Steam Cylinder Indicator Cards,
Compressor Cylinder Indicator Cards,
Samples of Coal and Ash,

No more data is necessary for a complete heat balance though other readings would be essential if it were deemed advisable to carry out a more detailed test on the boiler.

The specifications for the compressor installation, of this plant, are bound herein and may be found by reference to the index.

For the benefit of those who will continue the experimental undertakings of those on this plant, particular of such a nature as will involve the theory of refrigeration, a thorough and up-to-date Bibliography is bound herein. This work was compiled under the direction of Mrs. Julia A. Beveridge, Librarian and for her untiring efforts in assisting this cause, the writers of this Thesis hereby express their indebtedness. For the assistance rendered by members of the Mechanical Department, said writers also feel grateful.

Respectfully submitted,

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- Some faults in ammonia compressors, — Feb. 1, 1908
- Ammonia compression system, — Apr. 1908
- Test of Compressor — Apr. 1908
- Fallacies of refrigerating theory, — June 1908
- Comparing ice machines and systems, — July 1908
- Compression vs. absorption plants, — July 1908
- Jacket water on single acting compressors, — Aug. 1908
- Compressor, operating together dry and wet — Jan. 1908
- Indicator for ammonia compressor, — Jan. 1909
- Practical limits, — Jan. 1909
- Calcium chloride vs. salt — March 1909
- Some early patents on ammonia compressor — March 1909
- Compression system, 13 to 1 ice made in — April 1909
- Compression vs. abs machines — April 1909
- First single acting ammonia compressor — May 1909
- Operating troubles in ice plant p.45 — Sept. 1909
- Efficiency of refrigerating machines — Oct. 1909
- Theory and construction of compressor valves — Oct. 1909
- Refrigerating machine, cooling to 63°F. with — Oct. 1909
- A cold storage evaporimeter for measuring humidity, — Nov. 1909
- A modern ice making plant, — Nov. 1909
- Questions on operation of ice plant p.270 — Dec. 1909
- Refrigerating machines p.77 — Jan. 1910
- Ammonia, — June 1910
- Cycle of refrigeration — July 1910
- Heat and production of cold, — Nov. 1910
- Working fluid in refrigeration — Nov. 1910
- Purity of commercial liquefied ammonia gas & apparatii for testing it. Journal of Industrial & Engineering Chemistry - — Jan. 1909

Journal of Industrial & Engineering Chemistry:

- Methods for testing commercial anhydrous, liquid ammonia, — Mar. 1910

Mechanical Engineer:

- Mechanical refrigeration, — Apr. 10,1908

National Engineer:

- Approximate average cost of making ice in plants of different sizes, each operating under similar conditions, — Nov. 1909
- Flooded system and its application to ice making and refrigerating plants, — Nov. 1909

Power:

Mechanical production of low temperatures	Dec. 1907
Mechanical production of low temperatures	June 23, 1908
Compression refrigerating systems,	Jan. 5, 1909
Wet vs. dry compression,	Mch. 9, 1909
Use of indicators in refrigeration,	Apr. 20, 1909
Capacity of refrigerating machines,	July 6, 1909
Artificial systems of refrigeration,	May 2, 1910
Mechanical refrigeration,	Aug. 9, 1910
Mechanical refrigeration,	Aug. 23, 1910
Elements of compression system,	Sept.20, 1910
Operation of compression system,	" 20, 1910
Types of ammonia compressors,	Oct. 4, 1910
Installing refrigeration system,	Nov. 22, 1910
Charging a refrigerating system,	Nov. 29, 1910

Practical Engineer:
Refrigerating machine operation, Apr. 9, 1909

Proceedings of the Amer. Society of Mechanical Engineers:
Preliminary report of the committee on a code of rules for conducting tests of refrigerating machines Apr. 1907

FOR LISTS OF PATENTS ON MACHINES SEE INDEX IN FRONT OF EACH VOLUME OF ICE AND REFRIGERATION:

Specific Heat of Co. Cl_2 Solutions between $35^\circ C$ and $20^\circ C$
Bulletin Bureau of Standards Feb. 1910

A Study in Cooling and the Performance of the enclosed double pipe cooler in particular
National Engineer Mar. 1911

California Journal of Technology:
Artificial refrigeration April 1909

Cold Storage & Ice:

Performance of ammonia compression machines	Dec. 1908
Standard method of testing refrigerating machines,	Dec. 1908
Comparison of the production of cold by compression of liquefiable gases and other methods,	Oct. 1908
Insulation,	Oct. 1908
Pistons, piston rings and cylinders of compressors,	June 1909

Cold Storage & Ice:		
Approximate average cost of making ice	Jan.	1910
More data on specific heat of calcium brine	Feb.	1910
Report on specific heat of brine	Jan.	1910
Ohio Society of Mechanical, Electrical & Steam Engineers		
Single and double acting ammonia compressors	Nov.	1908
Power:		
Pressures in refrigerating system,	Dec. 13,	1910
Operating notes on refrigeration,	Dec. 6,	1910
Ice & Refrigeration:		
Clearance and efficiency,	Jan.	1911
Clearance in single and double acting compressors,	Dec.	1910
Practical constants in theory of refrigeration,	Jan.	1911

M-196 3-09-2000

York Manufacturing Company

MANUFACTURERS OF

Ice Making

and

Refrigerating Machinery

For All Purposes

Works and General Office: YORK, PENNA.

Established 1875 Incorporated 1894

M-197-3-09-3000

York Manufacturing Company

MANUFACTURERS OF

Ice Making and Refrigerating Machinery

Works and General Office: YORK, PENNSYLVANIA

PROPOSAL AND SPECIFICATION

Dated.......June 10, 1910.....

To.......ARMOUR INSTITUTE,

C H I C A G O,

I L L I N O I S.

We hereby propose to furnish you machinery and apparatus in accordance with the following specifications.

YORK MANUFACTURING COMPANY

Page.....1.... and.......A. I.

York Manufacturing Company will furnish..one........Machine.....same......to be in accordance with the following specifications:

STEAM ENGINE.

One..............Steam engine of our improved horizontal..type with cylinder.....6....inches bore........6....inches stroke Cylinder will be lagged and packed with mineral wool.

Governor will be of . standard ...type.

Valve gear will be of...slide valve.......type, and all parts of valve gear and governor will be of the best workmanship and material.

Steam stop valve.

Sight feed cylinder lubricator.

GAS COMPRESSION PUMPS.

One..........Gas pumps of our patented improved........Vertical Single........acting type. .6.............inches bore.....6.........inches stroke, fitted with cooling jacket and properly lagged.

Pumps fitted with special ammonia stop valves, with main pipe connections.

Latest improved stuffing boxes.

Pump provided for lubricating pump cylinder and stuffing boxes.

One duplicate set of pump valves.

Special by-pass valves and pipes on machine between pumps, enabling charge of ammonia to be drawn from one part of pipe system and stored in another part.

Compressor provided with false head.

MAIN SHAFT.

Of best forged and hammered steel.... ...3.....inches in diameter.

FLY-WHEEL.

Two ....Fly-wheels....3.... ..feet in diameter, to weigh about...... 500...... ..pounds each

DETAILS.

Connecting rods [illegible] of steel.

Oil cups and oiling [illegible] for continuous running.

Steel piston rods.

Pump frames of our standard......Export.....

Machine No. 1.

Page ......2.

YORK MANUFACTURING COMPANY

and...

Compressors driven direct from main engine shaft.

Pistons fitted with metallic packing.

Piston rods fitted with soft packing.

All wearing and bearing surfaces fitted with automatic oilers.

Machine will be complete as usually furnished by us.
Indicator connections on compressor.

AMMONIA GAUGES.

One set of ammonia pressure gauges, one for high pressure and one for low pressure, set on ornamental plate.

PLANS, FOUNDATION TEMPLATE AND BOLTS.

Complete plans will be furnished for foundations and for erecting the apparatus to suit the premises.

Foundation bolts with anchor washers and template for setting same.

WRENCHES, SMALL TOOLS AND TOOL BOARD.

One set of wrenches and small tools for taking machine apart for examination or to make adjustments of any part of engine and pumps.

One tool board arranged to receive the above tools.

FINISH AND PAINTING.

All parts of the machine that are machine tooled will generally be polished.

Machine will be given a priming coat of paint before shipment.

After machine is erected upon its foundation purchaser will tastefully paint and varnish the same.

THERMOMETERS AND OTHER INSTRUMENTS.

One glass test jar, one hydrometer for testing ammonia, and one chemical hand thermometer and where brine is used, one salt gauge for testing density of brine.

GUARANTEE OF DUTY FOR MACHINE.

The York Manufacturing Company hereby guarantees that............this....Machine consisting of the herein described engine and gas pumps, under test will give a duty equal to the...melting........of ..three........tons of ice in twenty-four hours, with an expenditure not to exceed.................gross tons of coal in twenty-four hours. The steam consumption of engine to be taken from indicator cards and the coal consumption figured upon a basis of an evaporation of 10 pounds of water into steam from and at 212° Fahr. per pound of dry coal.

PROPOSAL AND SPECIFICATION

AMMONIA CONDENSERS.

Will be our improved...double pipe....style, and will consist of..........one.........coils of 1-1/4" & 2"....ammonia pipe. Each coil will be........three...........pipes high, about......19. feet long, and will be provided with needed valves, headers, and water distributing devices.

Purchaser will furnish suitable water-tight floor or pan with needed drains.

AMMONIA RECEIVER AND OIL SEPARATOR.

One ammonia receiver. One oil separator. Separator and receiver will be of our latest improved style.

AMMONIA PIPE, VALVES, CONNECTIONS AND FITTINGS.

All valves, fittings, and ammonia pipe needed to connect the compressor pumps with the condenser and receiver.

CONDENSING WATER.

The purchaser hereby agrees to supply needed water at all times.

GUARANTEE OF CONDENSER CAPACITY.

The York Manufacturing Company guarantees that the above Ammonia Condenser will have refrigerating capacity of....three.....tons with water at 60° Fahr.

York Mfg. Company will furnish one section double pipe brine cooler, 6 pipes high, of 1-1/4" and 2" pipe, 13' long, with accumulator and connections for operation on Flooded System.

Thermometer wells will be placed in ammonia and brine connections wherever needed.

YORK MANUFACTURING COMPANY

and..............................A.A.

CONTRACT

THIS AGREEMENT, made this.............................day of.........................190....

by and between the York Manufacturing Company, a corporation duly incorporated under the laws of the State of Pennsylvania, having its principal office in the City of York, York County, Pennsylvania, party of the first part, and.......Armour Institute,

Chicago,

Illinois,

party of the second part, WITNESSETH:

The party of the first part agrees to construct for and deliver to the party of the second part on....... board cars Chicago, Ills. the machinery, apparatus or plant mentioned and described in the specifications hereto attached, which specifications, together with the agreements and guarantees therein contained on the part of each of the parties hereto to be kept and performed, are hereby expressly made a part of this agreement. The premises of the party of the second part, in which the said machinery, apparatus or plant is to be placed, are situated in the ....of....................................county of................................ state of..............................at No..street.

The party of the second part agrees to pay the party of the first part for the said machinery, apparatus or plant, the sum of.....Six Hundred and no/100 - ($600.00) - - dollars as follows, TO WIT:..............................

Contract—No. 1.

Page........5

YORK MANUFACTURING COMPANY

and........................A.I.

....

....

....

....

....

The party of the first part will have the machinery, apparatus or plant ready for charging on or about the ....day of.. 191...., provided the purchaser shall have performed within the time limited therefor all agreements by him to be kept and performed as set forth in the attached specifications.

When and as the whole or any portion of the said machinery, apparatus or plant shall be delivered on the premises of the party of the second part, said party of the second part will immediately cause the same to be insured against loss or damage by fire in Insurance Companies to be approved by the party of the first part hereto in an amount equal to the purchase price thereof; the loss or damage under such policies to be made payable to the party of the first part as its interest may appear; and the said policies to be maintained in force by the party of the second part until the entire purchase price herein agreed to be paid, shall be actually received by the party of the first part in cash.

It is further expressly agreed that the title to and ownership of the machinery, apparatus or plant herein contracted for shall remain in the York Manufacturing Company until the entire purchasing price herein agreed to be paid, and all notes and other securities given to secure the same or any part thereof, shall be actually paid in cash; and in case of failure or refusal on the part of the party of the second part to make the payments, or any of them, when due under this contract, or to make settlement by the execution and delivery of notes or other obligations as hereinbefore agreed, or to pay any note that may be given the party of the first part when the same shall fall due, that then and in any of such events the whole of the unpaid portion of the purchase money, howsoever secured and whenever payable, arising under this contract, shall thereby at the option of the said party of the first part become immediately due and payable; or, in case of such default on the part of the party of the second part, the party of the first part shall thereupon have the right to enter upon the premises upon which such machinery, apparatus or plant is installed, and, by its agents, representatives and employees take possession of and remove the same, and the party of the second part shall afford every facility therefor; and it is hereby further agreed that in case said machinery, apparatus or plant shall be taken by the party of the first part under this agreement by reason of default by the party of the second part as hereinbefore set forth, that then and in any such case the party of the second part shall pay the party of the first part all expenses incurred by the party of the first part under this contract,

and for all damages to the party of the first part arising from the wear and tear of the said machinery, apparatus or plant, and such further sum of money as will reasonably compensate the party of the first part for the use or rental by the party of the second part of the said machinery, apparatus or plant, which said rental is hereby fixed and agreed to be six per cent. per annum upon the total purchase price herein agreed to be paid, and to be calculated from the date when the machinery, apparatus or plant herein contracted for, is erected ready to charge; but the foregoing provisions shall in no wise alter or impair the obligations of the party of the second part to keep said machinery, apparatus or plant in good condition while in the custody of the party of the second part, nor in any wise release the party of the second part from the liability to pay to the party of the first part all damage to such machinery, apparatus or plant which may be occasioned by the negligence, carelessness or abuse thereof by the party of the second part, his representatives or employees.

And it is further agreed by the party of the second part that the party of the first part shall have the right to file a Mechanics' Lien for materials and labor furnished under this contract, and this stipulation is hereby declared to be notice to the party of the second part, owner or reputed owner of the property, as given at the time of furnishing the materials and labor for said plant or for said repairs, alterations or additions herein provided for, of the intention to file a lien and a waiver of any other notice of such intention.

All of the agreements herein set forth are hereby made binding upon and enforceable by the heirs, executors, administrators, successors and assigns of the respective parties hereto.

This contract shall only become operative when the same shall have been approved in writing by the President or Vice-President, and the Secretary or Treasurer of the York Manufacturing Company and attested by its corporate seal.

In witness whereof the parties hereto have duly executed these presents this......15th.........
day of.....June..............1910.

York Manufacturing Company,
By.. W H Gaylord...............
....
....
....
....

Approved by the York Manufacturing Company at York, Pa......................................
day of............................190 .

York Manufacturing Company,
By..President.
....Secretary.

Contract—No. 3. YORK MANUFACTURING COMPANY
Page.....7... and..............................A.I..............................

6-16-10.

File 247

Mr. F. U. Smith,

Armour Institute.

I have changed your order 6295 to read one 3-ton Refrigerating plant as per conversation with Mr. Gebhardt yesterday. The price will be $600 f.o.b. Chicago. We enclose copy of specifications for your files.

F J Reynolds.

R-M

Proposal

Specification

and Contract

York Manufacturing Company

and

PLATE I.

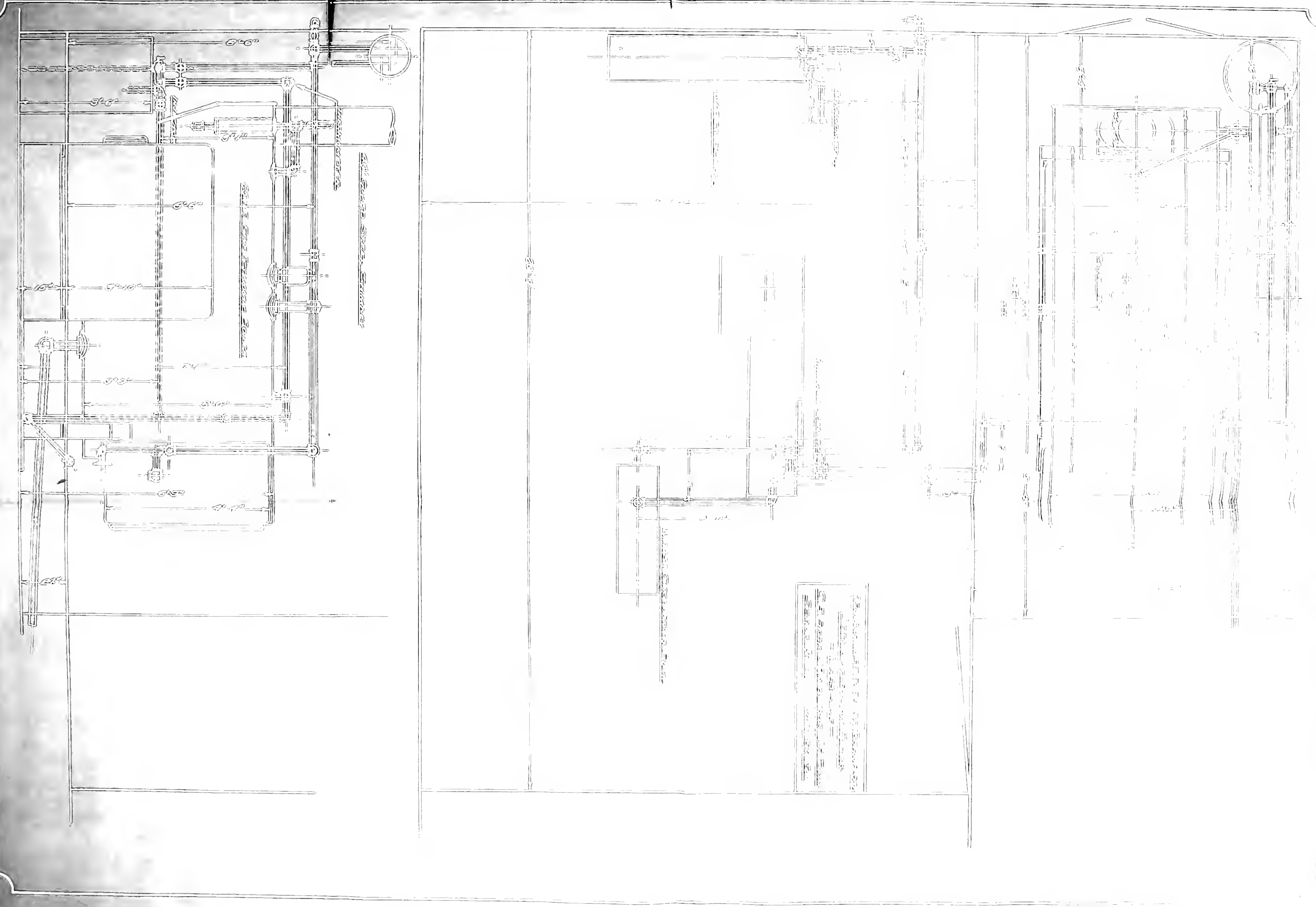


PLATE II.

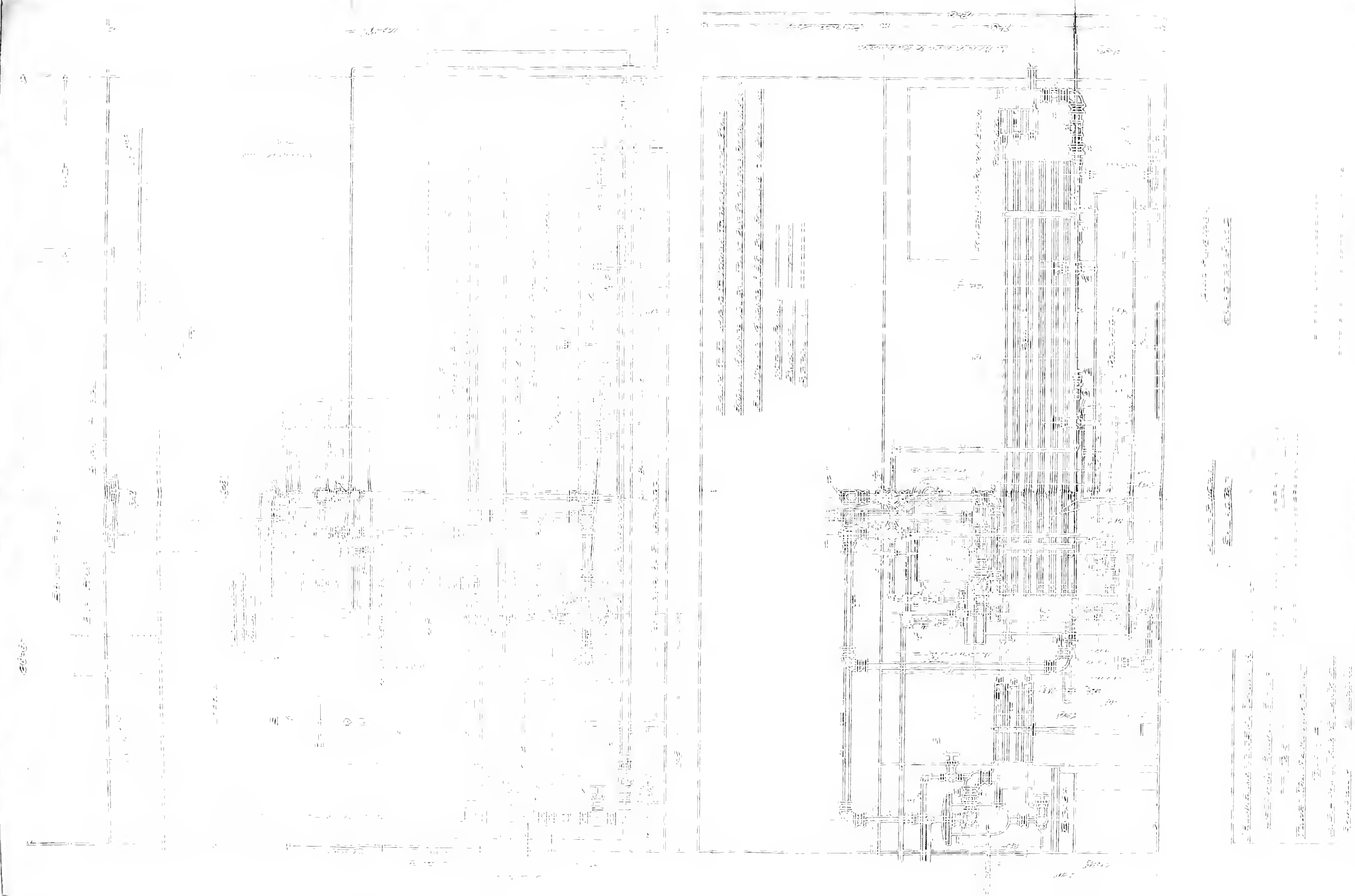
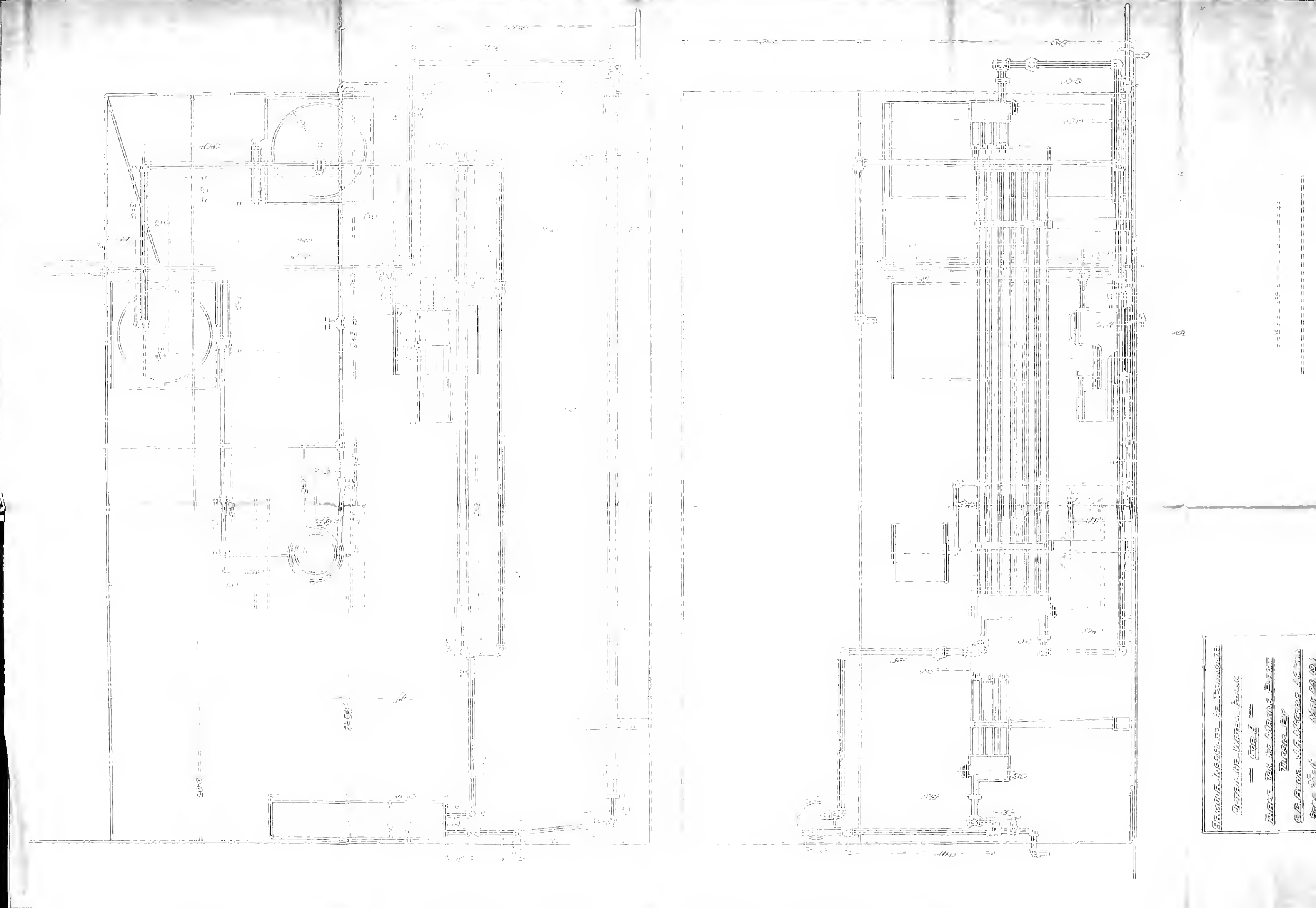


PLATE III.



Armour Institute of Technology
Design of Water Piping
— For a —
Three Ton Ice Making Plant
Thesis By

PLATE V

PLATE VI

D 2nd

PLATE VIII

[illegible]

2"x1½"
1½"

2876-F
1551-F

4
4

1
2

1¼"

2015-F

1¼"
1¼"

3-
19'-0"

½"

1240-C

C. C.

Armour Institute of Technology
Chicago, Ill.

DRAFTING DEP'T
SEP 6 - 1910
APPROVED..............

July 13.1910

2

28103.

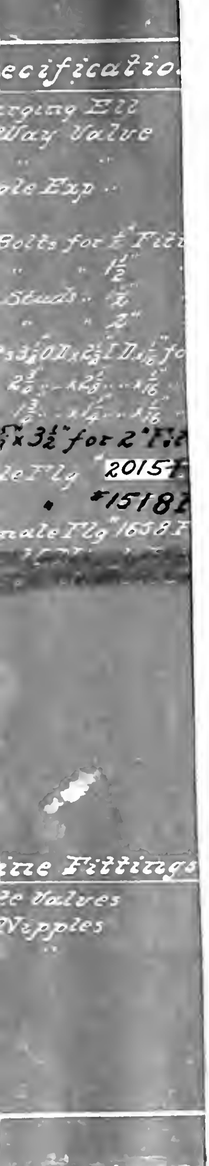


PLATE VIII

2"x1½"	2876
1½	1551

4

2

2

4 Bolts ⅝"x3½" for 2" Fittings
1¼ 2015-F
2 " " #1518 F tapped 1¼"

6
13'-0"
1¼" & 2" Pipe

1¼ Accumulator

1¼

(2)

(2)

#3015-F

1240-C
C. C.

Armour Institute of Technology
Chicago, Ill.

July 13, 1910
3
28103.

[illegible] 2 [illegible]

PLATE IX

D 2 [illegible]

3

½"x½"x½" 1643

3

½ 12

½

379

½ System ½

20"

¼ 21"

½ 1838

½

24

12

1240-C

½

Armour Institute of Technology
Chicago, Ills.

8 0

1 Steel

July 13, '10.

21

28103

PLATE X

[illegible]